

NATIONAL BUREAU OF STANDARDS REPORT

5959

RECHECK OF LAMPS USED IN INTERCOMPARISONS
OF
STANDARDS OF LUMINOUS INTENSITY AT 2353°K
AT
BUREAU INTERNATIONAL DES POIDS ET MESURES

by
Ray P. Teele
Velma I. Burns



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Photometry and Colorimetry Section
Optics and Metrology Division

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Recheck of Lamps Used in Intercomparisons
of Standards of Luminous Intensity at 2353°K
Made at Bureau International des Poids et Mesures

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In "Lettre-circulaire du Bureau International aux Laboratoires Nationaux," dated October 28, 1957 the first two lines of Table A indicate that our 1956 candela is larger by 0.8 percent at 2042°K and larger by 1.3 percent at 2353°K than our 1952 candela. Since we have attempted to maintain these units constant, a study has been made to determine whether these indicated changes are apparent or real. The candela at 2353°K was studied first because it had the greater indicated change. It is the purpose of this report to give new data and analyses of the previous determinations bearing on this point. A subsequent report will deal similarly with the candela at 2042°K.

Table A herein lists the groups of lamps sent to the BIPM for the 1952 and 1956 intercomparisons and of similar lamps retained here, the standards used for their evaluation, and the equipment used. Tables B and C summarize the results previously reported for the 1956 intercomparisons. In reviewing these results and studying the apparatus used, it was noted that the latter included a horizontal bar photometer equipped with a special set of baffles. Examination of these baffles showed that the baffle closest to the lamp acts as a diaphragm and excludes from the photometric receiver some light reflected from the upper parts of the bulbs of the lamps submitted to the BIPM for the 1956 comparisons though they did not do so for the lamps submitted to the BIPM for the 1952 comparisons. This difference in conditions is identified in Table A under "Equipment Used" by the phrases "Exposed" and "Baffled". Check measurements were accordingly made (12/57 and 2/58) of the lamps (Group 3764) sent to the BIPM for the 1956 intercomparisons by comparing them with the same standards (Group 2987) used for the "Before" (10/55) and the "After" (6/57) measurements. Three runs were made under the same conditions, as nearly as possible, used for the "Before" and "After" measurements reported in NBS Reports 4341 and 5317 except that the entire lamp was exposed to the photosensitive surface of the photometer by using tall baffles. Three runs were also made on a completely different set-up, again with the entire lamp exposed to the photometer. Finally two check runs were made on the latter set-up, one by the balance method, one by the Kohlrausch method.

Table A - Summary of the comparisons at NBS relating to the lamps sent for the 1952 and 1956 BIPM inter-comparisons of the candela at 2353°K

Date	NBS report	Lamps measured	Standards used	Equipment used	Number of runs
9/48	118,363	BS3435* BS3436* BS3437* BS3438*	BS4923 BS4924 BS4925 BS4926 BS4927 BS5470 BS5472 BS5473 BS5477 BS5478 BS5467	209 Exposed	3
5/52	1664	BS3435* BS3436* BS3437* BS3438*	BS2987 BS2990 BS2991 BS2992 BS2993 BS2986 BS5470 BS5472 BS5473 BS5477 BS5478 BS5485	209 Exposed	3
10/55	4341	NBS3764* NBS3765* NBS3767 NBS3768 NBS3769* NBS3770* NBS3771	BS2987 BS2990 BS2991 BS2992 BS2993	209 Baffled	3
6/57	5317	NBS3764* NBS3767 NBS3768 NBS3769* NBS3770* NBS3771	BS2987 BS2990 BS2991 BS2992 BS2993	209 Baffled	3
12/57-Present 2/58		NBS3764* NBS3767 NBS3768 NBS3769* NBS3771	BS2987 BS2990 BS2991 BS2992 BS2993	209 Exposed) Kohlrausch) Balcony,) Exposed) 4 Balance, 1 Kohlrausch	3 5
2/24/58-Present		NBS3764* NBS3767 NBS3768 NBS3769* NBS3771	NBS3764* NBS3767 NBS3768 NBS3769* NBS3771	209, one run Baffled, one Exposed	2

* Lamps sent to BIPM

Table B - Values of Candela at 2353°K in "Before"
Measurements (10/55)
(Kohlrausch 209, special baffles)

Lamp No.	Amperes	Candela	Uncertainty
NBS3764	0.3402 ₀	22.38	±0.12
NBS3767	.3434 ₃	21.74	±0.22
NBS3768	.3482 ₈	22.82	±0.33
NBS3769	.3402 ₃	22.03	±0.15
NBS3771	<u>.3462₃</u>	<u>21.92</u>	±0.21
Average	0.34367	22.18	±0.30

Table C - Values of Candela at 2353°K in "After"
Measurements (6/57)
(Kohlrausch 209, special baffles)

Lamp No.	Amperes	Candela	Uncertainty
NBS3764	0.3403	22.30	±0.33
NBS3767	.3437	21.61	±0.09
NBS3768	.3483	23.00	±0.12
NBS3769	.3407	22.04	±0.04
NBS3771	<u>.3464</u>	<u>21.99</u>	±0.09
Average	0.3439	22.19	±0.11

Table D - Values of Candela at 2353°K in "Present"
Measurements (12/57 - 2/58) Tall Baffles

Lamp No.	Amperes	Candela	Uncertainty
NBS3764	0.3403	22.62	±0.08
NBS3767	.3437	21.98	±0.06
NBS3768	.3483	23.23	±0.09
NBS3769	.3407	22.27	±0.09
NBS3771	<u>.3464</u>	<u>22.28</u>	±0.10
	0.3439	22.48	±0.05

Table E - Summary of results on the candela at 2353°K of lamps in 1956 intercomparisons

Conditions	Measurement	Number of runs	NBS3764*	NBS3767	NBS3768	NBS3769*	NBS3771	Mean
<u>Baffled</u>								
209	"Before"	3	22.38	21.74	22.82	22.03	21.92	22.18
209	"After"	3	22.30	21.61	23.00	22.04	21.99	22.19
<hr/>								
Mean baffled (6 runs)			22.34	21.68	22.91	22.04	21.96	22.19
<hr/>								
<u>Exposed</u>	Equipment used							
209	Kohlrausch	3	22.60	21.95	23.17	22.30	22.21	22.45
Balcony	Balance	3	22.63	21.99	23.24	22.25	22.33	22.49
Balcony	Balance	1	22.55	22.01	23.32	22.22	22.37	22.49
Balcony	Kohlrausch	1	22.68	22.04	23.29	22.28	22.26	22.51
<hr/>								
Mean exposed (8 runs)			22.62	21.98	23.23	22.27	22.28	22.48
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Ratio:	exposed to baffled		1.013	1.014	1.014	1.010	1.015	1.013

* Lamps sent to BIPM in 1955 and returned in 1956

Table D gives the average of the results of the eight "Present" runs. Of the five lamps mentioned in this table, three (NBS3767, NBS3768, NBS3771) had been retained at this Bureau, and two (NBS3764, NBS3769) had been sent to the BIPM in 1955 together with lamps NBS3765 and NBS3770. Lamp NBS3765 was excluded from the "present" measurements because it was found at the BIPM to have a loosened base, and the other (NBS3770) was excluded because of damage to it during the "After" measurements.

Table E summarizes the intensities found for these five lamps, giving not only the "Before" and "After" results from Tables B and C, but also the separate results of the two three-run sets of measurements and each of the two check runs whose averages only are reported in Table D. In the column labeled "conditions" in Table E "Balcony" indicates the new set-up, and "209" indicates the set-up used in the "Before" and "After" measurements. In the column labeled "Measurement", "Kohlrausch" refers to the use of a Kohlrausch "zero-resistance" circuit to measure photo-cell current, and "Balance" indicates that the currents of two photo-cells, one illuminated by the test lamp and one by a comparison lamp, were balanced, the intensity ratios being found from measured lamp distances.

It will be noted from the ratios, exposed to baffled, in Table E that the "present" luminous intensities of the whole lamps exceed the former luminous intensities of the lamps baffled to exclude reflections near the top of the bulb by percentages ranging between 1.0 and 1.5. The average percentage for the two lamps sent to BIPM is 1.2, and the average for all five lamps is 1.3, both of which correspond closely to the apparent increase of 1.3 percent reported by the BIPM for the 1956 NBS value of the candela over the 1952 value. Since we presume that the BIPM measurements took into account light from the whole of the lamp including that by reflections near the top of the bulb, it may be tentatively concluded that the apparent increase in the NBS value of the candela at 2353°K is ascribable to our exclusion of these reflections to obtain the results given in NBS reports 4341 and 5317.

As a further check on this point, two runs were made on this group of five lamps with the special set of baffles extended as we believe they were in the "Before" and "After" work, and with the baffles set to expose the entire lamp. The ratio of the intensity found for the entire lamp exposed to the intensity found for the condition excluding the reflections was 1.010.

It is concluded that the values given for the intensities of the lamps sent in 1955 to the BIPM to represent our value of the candela at 2353°K did not in fact do so, but instead represented a unit of intensity higher than our value of the candela by a percentage probably somewhere between 1.0 and 1.5. If, as we presume, the BIPM measurements took account of light from the entire lamp, this result explains why the BIPM measurements indicated an increase in our value of the candela by 1.25 percent.

U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



THE NATIONAL BUREAU OF STANDARDS

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Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

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